

Welcome to Workshop on U.S. Land Use/Land Cover Scenarios and Projections

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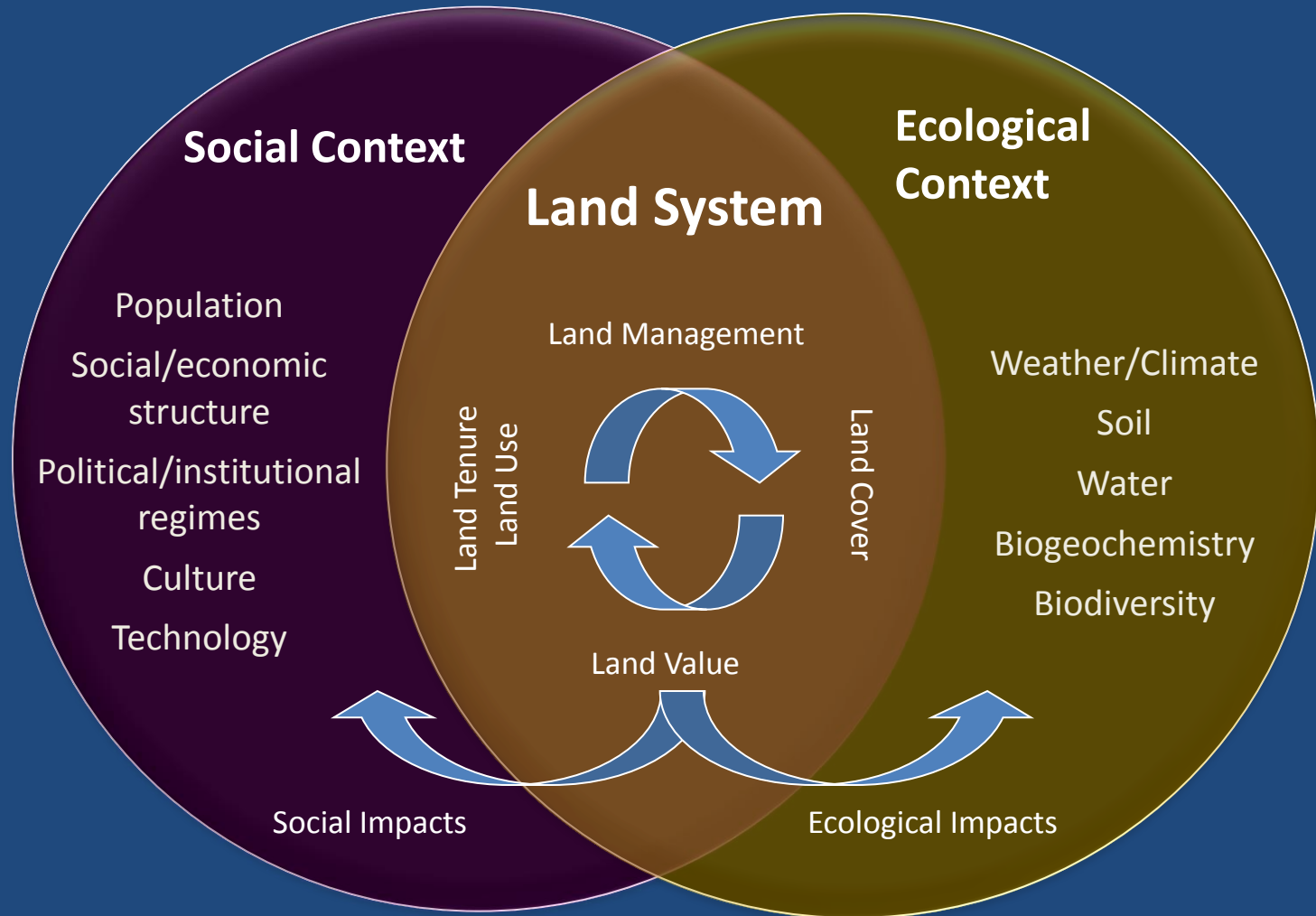
Workshop Science Steering Committee

- Dan Brown (University of Michigan) co-Lead
- Richard Moss (PNNL) co-Lead
- Budhendra Bhaduri (Oak Ridge)
- Chris Justice (University of Maryland)
- Mark Levy (Columbia)
- Ruben Lubowski (EDF)
- Ben Sleeter (USGS)
- Allison Thomson (PNNL/JCGRI)
- Dave Wear (USFS)

Workshop goals

- Identify key natural, physical, socioeconomic, and policy variables affecting LULCC.
- Identify key gaps in data, modeling, and analysis capacity, etc. related to projecting LULCC under a changing climate to inform future research needs.
- Scope preliminary LULCC scenarios to gain insights into framing, contextual variations, methodological approaches, and paths forward for developing U.S. LULCC scenarios that can be applied to federal assessments and land management needs.

Land Systems



Land-Change Variables

- **Land Cover** – biophysical land characteristics
- **Land Use** – persistent human activities on land
- **Land Management** – activities within a land use that affect land productivity and outcomes
- **Land Tenure** – access and rights to land
- **Land Value** – economic, cultural, ecosystem or other worth
- **Land Systems** – the set of land characteristics, actors, interactions, and contexts that produce land change

Implications of Land Change

- Land-climate interactions
- Water quantity and quality
- Biotic diversity, ecosystem function, and tradeoffs among ecosystem services
- Food and fiber production
- Energy and carbon (sequestration)
- Urbanization, infrastructure, and the built environment

Two Antecedents

- National Research Council's report on land change modeling
 - see Brown webinar
- Land use and land cover change chapter in the Third National Climate Assessment
- IPCC scenario process (SRES, RCP, RAP, SSP, etc.)
 - see Moss/O'Neill webinar



ADVANCING LAND CHANGE MODELING

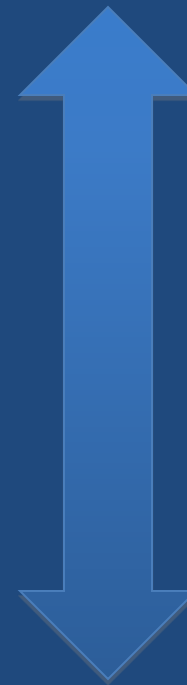
Opportunities and Research Requirements

NATIONAL RESEARCH COUNCIL
OF THE NATIONAL ACADEMIES

Modeling Approaches

Five overlapping approaches and hybrids were identified to evaluate their analytical capabilities and science and policy applications

- Machine learning
& Statistical
- Cellular
- Economic
 - Sector-based
 - Spatially disaggregated
- Agent-based



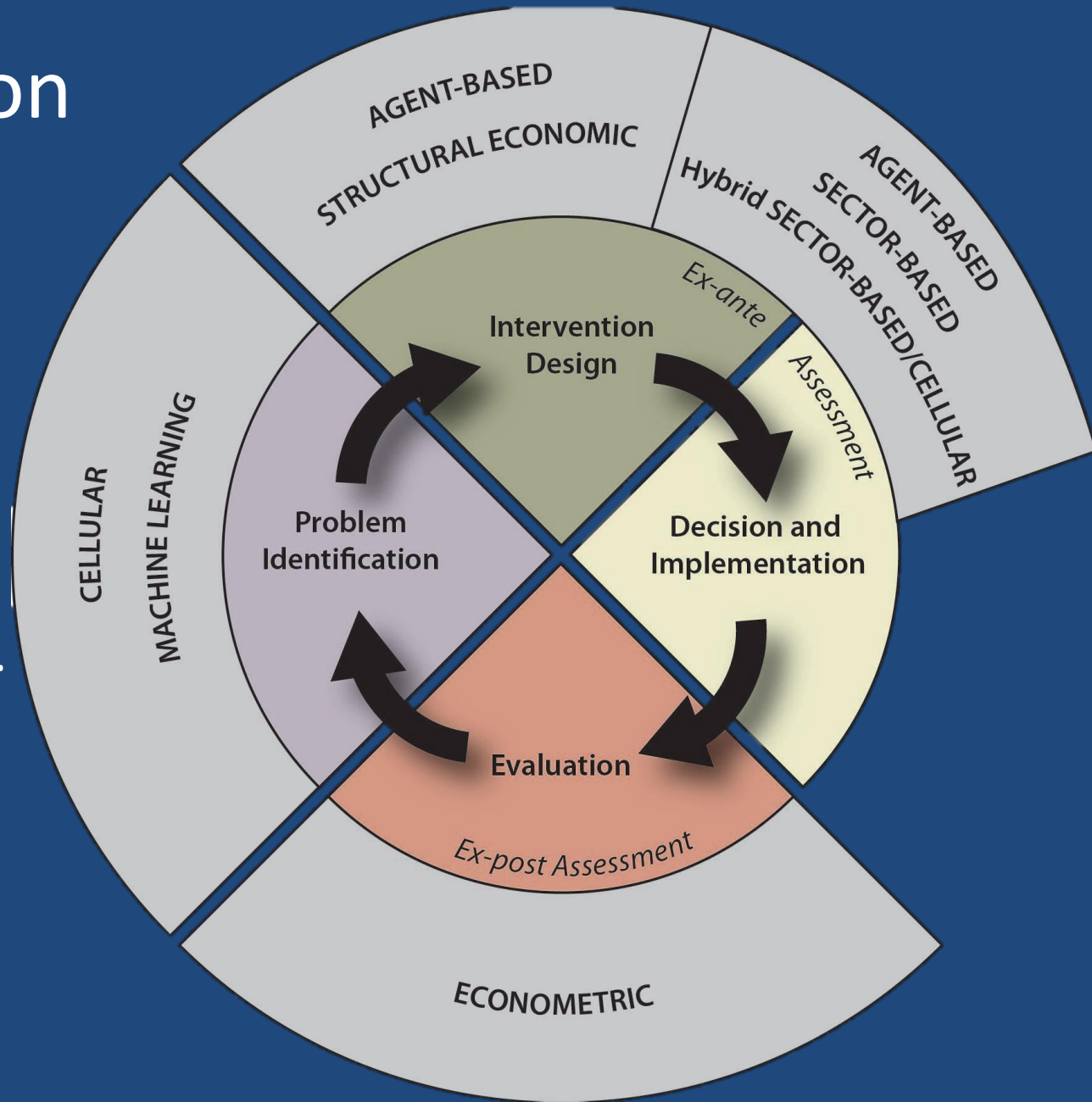
Land Cover

Land Use

Comparison

Considering the various goals of in the decision making process, different modeling approaches serve these different goals.

Model selection needs to consider match of approach to goals.



Comments on Approaches

- *Machine learning, statistical, and econometric approaches* based on data from the past.
 - Direct projection generally assumes stationarity
- *Sector-based approaches* tend to operate at coarse spatial resolutions, e.g., whole regions.
- *Agent-based models* may not reflect common economic assumptions, and face data and computational challenges.

Opportunities in LCM Research

- *Advancement of process-based, structural approaches*
 - Required for policy analyses like PES schemes.
 - Expanding models to include teleconnections and social networks
- *Cross-scale integration of models*
 - Bridging knowledge from aggregate and disaggregate approaches.
- *Cross-scale integration of LCMs and Earth System models*
 - Need models that address biophysical, like impervious to link with hydro models, albedo to link with climate models.
- *Bridging LCMs optimization and design-based approaches*
 - Simulating outcomes that are **possible** and those that are **desirable**
 - Provides links to design and planning

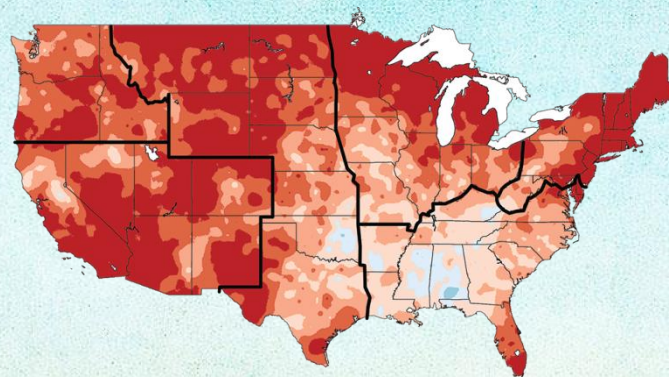
Scenario and Simulation



- Based on “Story and Simulation” approach (Alcamo 2008)
- Scenarios provide qualitative description of plausible futures.
- Models are used to simulate quantitative outcomes based on the qualitative scenarios.

Third National Climate Assessment

Climate Change Impacts in the United States



Four Key Messages

- LULCC has affected and will continue to affect how vulnerable or resilient human communities and ecosystems are to the effects of climate change.
- LULCC affect local, regional, and global climate processes.
- Land-use decisions can help adapt to the effects of climate change.
- Choices about LU may provide a means of reducing atmospheric greenhouse gas levels.

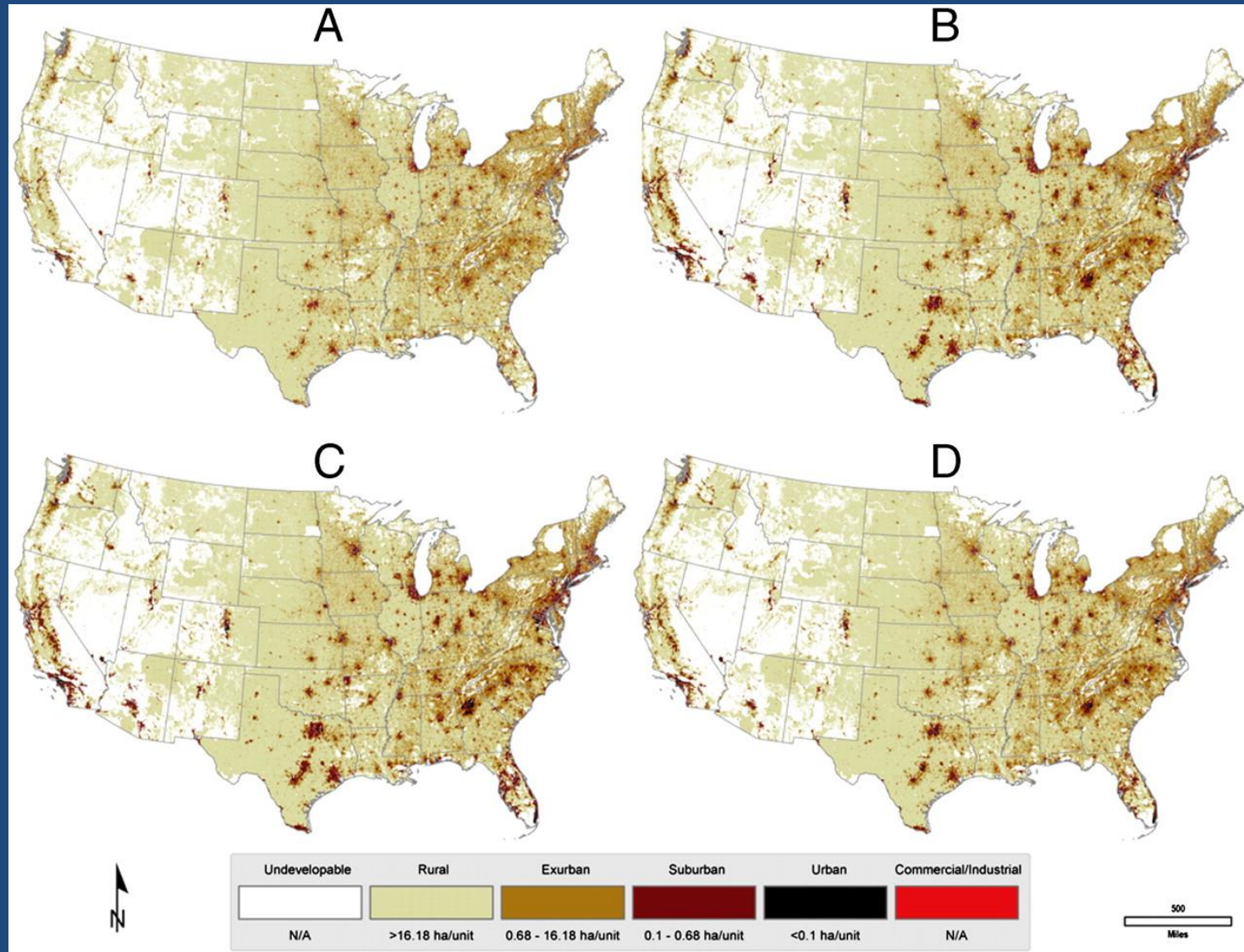
Scenarios and Projections

- Based on two projects
 - EPA Integrated Climate and Land Use Scenarios (ICLUS)
 - Bierwagen et al. 2011 *PNAS*
 - USDA Forest Service land use forecasts for the Resources Planning Act (RPA) resource assessment (Wear/Langner presentation)
 - Wear 2011. USDA FS GTR, SRS-141.

EPA ICLUS/SERGoM

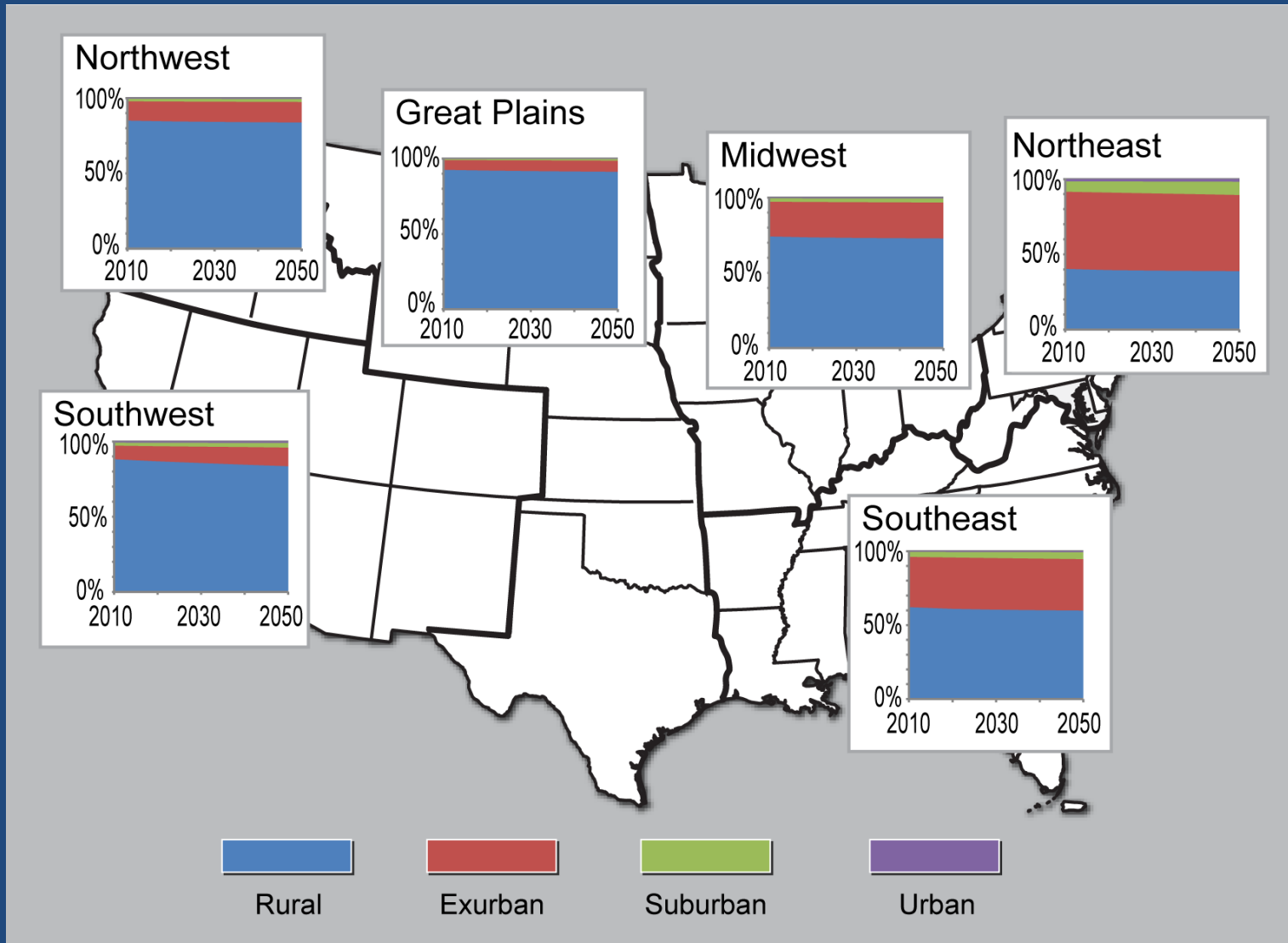
- Projected county-level percentages in housing-unit densities to 2100 based on population forecasts assuming demographic and economic growth consistent with four SRES scenarios.
- Cohort-component modeling based on forecasts of demographic components from US Census.
- Downscaled to 100 m (1 ha) cells using distance and NLCD-based weightings.
- Percent impervious surface area estimated using regression tree models.

Housing density for the conterminous United States shown as (A) actual housing density in 2000; (B) modeled housing density in 2100 for base case; (C) for scenario A2; and (D) for scenario B1.



Bierwagen B G et al. PNAS 2010;107:20887-20892

Projections of Settlement Densities (2010-2050)



Forest Service RPA

- Projected county-level population and income to forecast percentages in each land-cover each decade to 2060.
- Econometric models for each of four regions based NRI data from 1987-1997.
- Assumes demographic and economic growth consistent with three SRES scenarios.
- Changes in forest, cropland, pasture, rangeland only due to urban expansion.

Urban Growth Forecasts

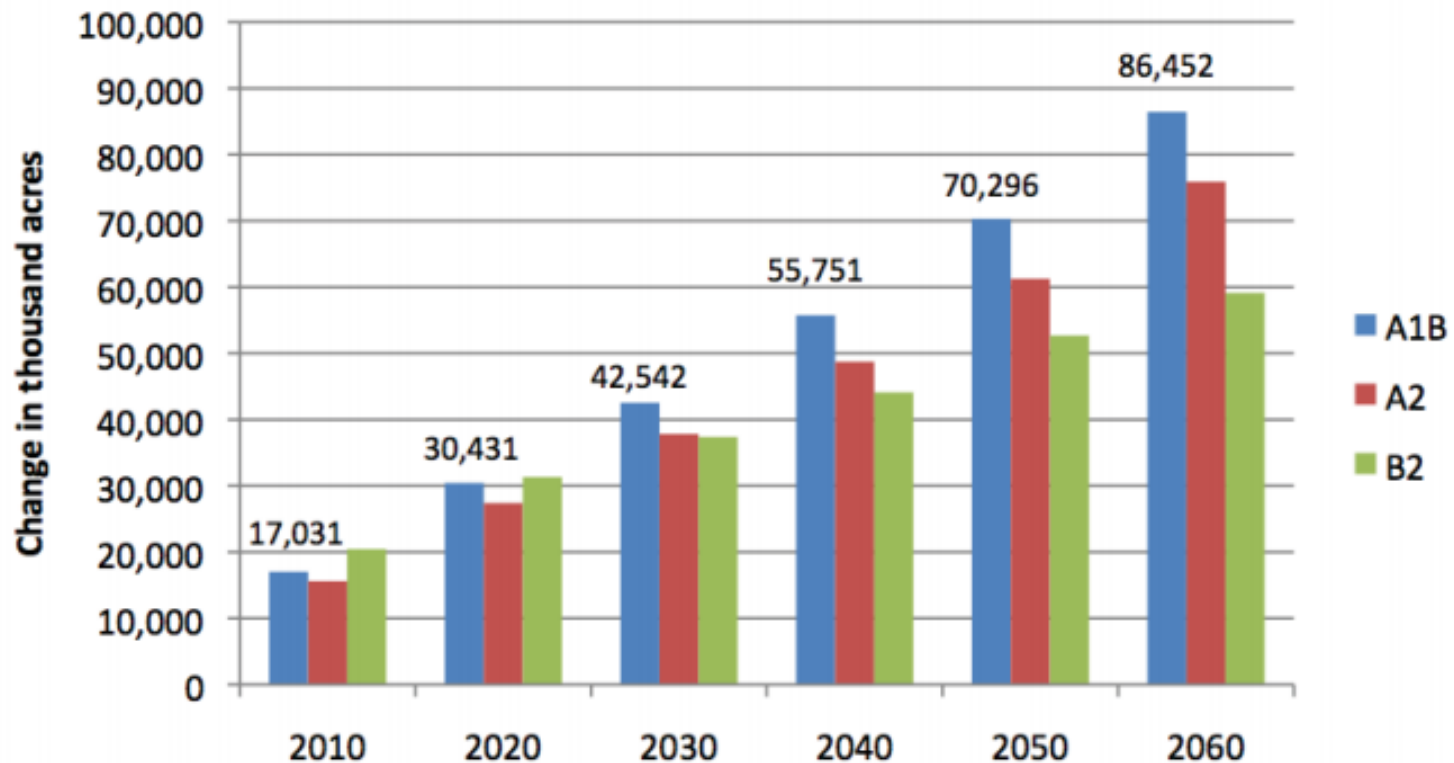
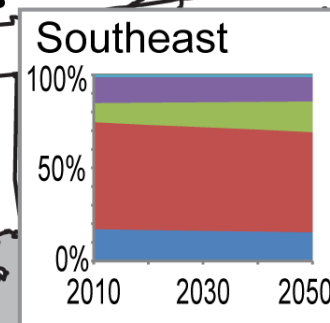
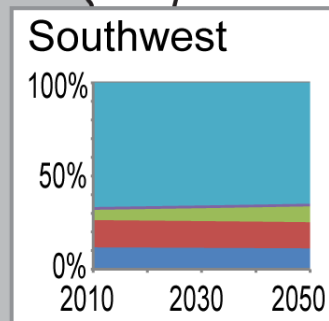
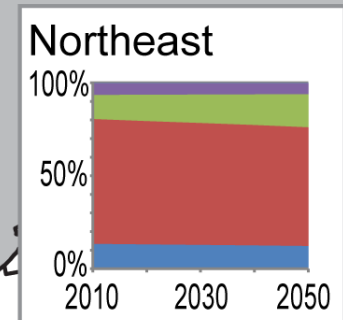
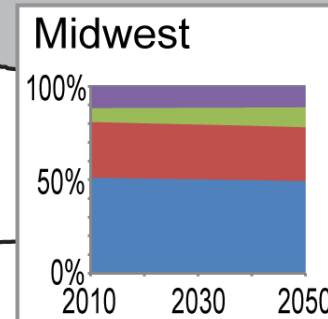
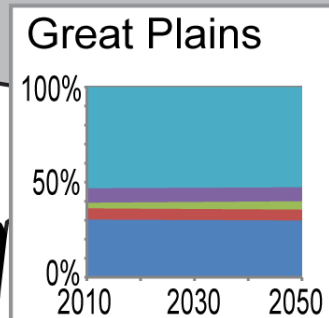
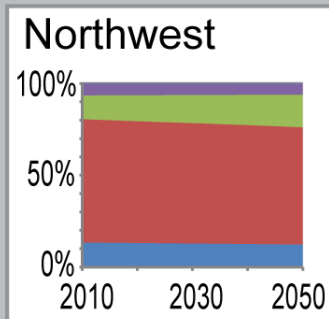


Figure 7—Forecasted change in urban land uses for the United States from a base year of 1997, 2010-2060, by Scenario (numbers are for A1B Scenario).

Projected Land Covers (2010-2050)



Cropland



Forest



Urban



Pasture



Rangeland

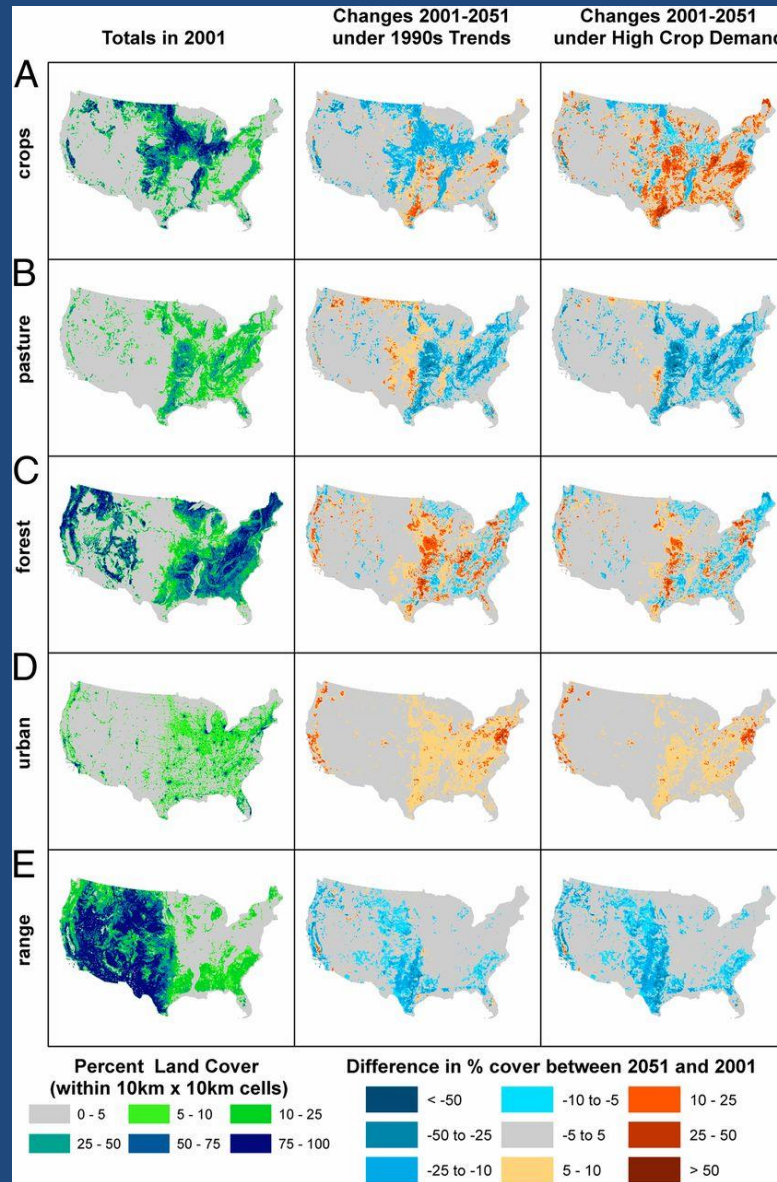
Other Scenario-Simulation Activities

- USGS Carbon Assessment (Sohl presentation)
- Lawler et al. 2014, *PNAS*
 - Use econometric model based on net returns to land use at the county level and NRI land use information, 1992-1997 (Lubowski presentation)
 - Estimate land uses for 100 m cells, modified for 2051 based on starting patterns in NLCD 2001.
 - Evaluated impacts of 2 trend and 3 alternative policy scenarios on carbon storage, species habitat, timber production, and food production.

Lawler Scenarios

- **Low crop prices** consistent with 1992-1997
- **Higher crop prices** similar to 2007-2012
- **Forest incentives** – financial incentives for afforestation and reduced deforestation
- **Natural habitats** – financial incentives for conservation of forest and rangeland to prevent conversion to crop land, pasture, or urban
- **Urban containment** – prohibition on urban land expansion in all nonmetropolitan counties

Spatial patterns in land cover in 2001 and changes between 2001 and 2051 under two baseline scenarios, 1990s trends and high crop demand.



Lawler J J et al. PNAS 2014;111:7492-7497

Structure of the Workshop

1. Defining user needs
2. Identifying key drivers and consequences of land-use change
3. Designing land-use scenarios
4. Identifying existing and needed resources for scenario construction and simulation (data, models, analyses, etc.)
5. Defining next steps